

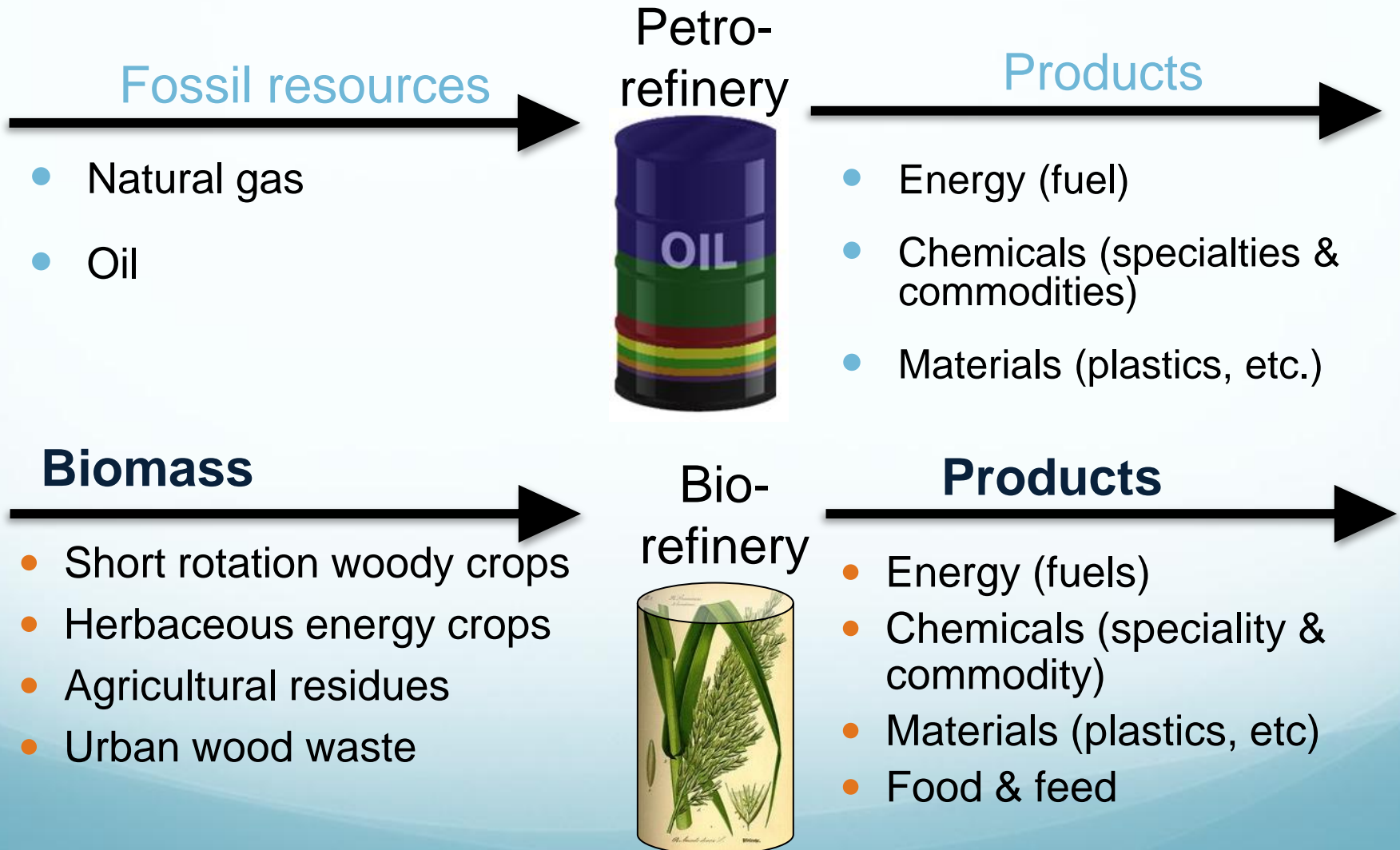
**Giant reed (*Arundo donax* L.):
how a “noxious weed” can
become a sustainable energy
crop for 2nd generation ethanol
in warm temperate climates**

S. Miele ⁽¹⁾, A. Pompeiano⁽¹⁾, E. Bargiacchi ⁽²⁾

**(1) Dep. of Agricultural, Food and Agro-environmental Sciences (DiSAAA),
University of Pisa (Italy), smiele@agr.unipi.it**

(2) Agronomist, Consortium INSTM, Firenze (Italy)

REPLACEMENT OF FOSSIL FUEL WITH BIOMASS



RENEWABLE ENERGY (RED) AND FUEL QUALITY (FQD) DIRECTIVES: THE TARGETS IN EUROPE

- 10% renewable energy for the EU transport sector by 2020 (RED)
- Minimum GHG saving requirements of biofuels to count towards the target:
 - 35% GHG saving compared to fossil fuel equivalent from implementation
 - Increasing to 50% from 2017 and 60% for new plants starting from 2018 (RED and FQD)
- Biofuels shall not be issued from high biodiversity or high carbon stock lands
- .../.....

....THE TARGETS

- Biofuels made from waste, residues, non-food cellulose and lignocellulosic (LC) materials count double towards the target (Art. 21.2)



THE CONSEQUENCE

- Non-food LC materials will be the pivot feedstocks for a sustainable renewable energy/biofuels production



HENCE

- A FLEXIBLE, RELIABLE PROCESS IS REQUIRED TO EXPLOIT DIFFERENT, POTENTIAL LC FEEDSTOCKS



WHICH MEANS

- ONE TECHNOLOGY FOR A BUNCH OF SITE-ORIENTED LC FEEDSTOCKS

INDEPENDENTLY UPON HOW AMBITIOUS TARGETS HAVE BEEN POSED

- R&D on perennial lignocellulosic crops should focus on attaining high yields with reduced inputs, especially water, and exploit surplus, marginal, low quality, abandoned lands → LUC & WUE

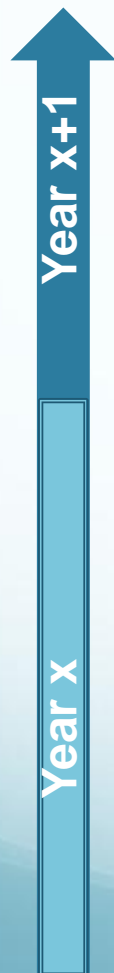
THE AGRONOMIST'S POINT OF VIEW

- Process technology is only one component of a successful biomass-processing chain project: (quite) the same industrial plant can be easily located in different areas
- BUT, any biomass-based process: power and thermal applications, or the refining into biofuels and chemicals, requires to focus a site-oriented biomass procurement plan and effectively manage the feedstock supply chain over the years
- To make this possible, WHAT IS THE BEST CROP MIX TO COPE WITH SOILS & SEASONAL VARIABILITY, IN A GIVEN AREA, AT A REASONABLE LEVEL OF IMPACT ?

WHAT KIND OF IMPACT ?

- A sustainable, biomass-based energy/fuel production chain, including its logistic system, should be not only productive and economical, but also environmentally and socially viable
- “Environmentally viable” means “low impact on resources”, “preserving ecological niches & biodiversity”, “promoting safer alternatives to present uses (misuses)”. “Socially viable” means “maintaining rurality” and the related activities (agro-industry)
- For a successful co-existence of food and non-food crops it is crucial to cultivate the latter crops starting from areas left fallow, set-aside, or lands that come from shifting of some traditional crop cultivation. Polluted areas are a starting point for a large public acceptance

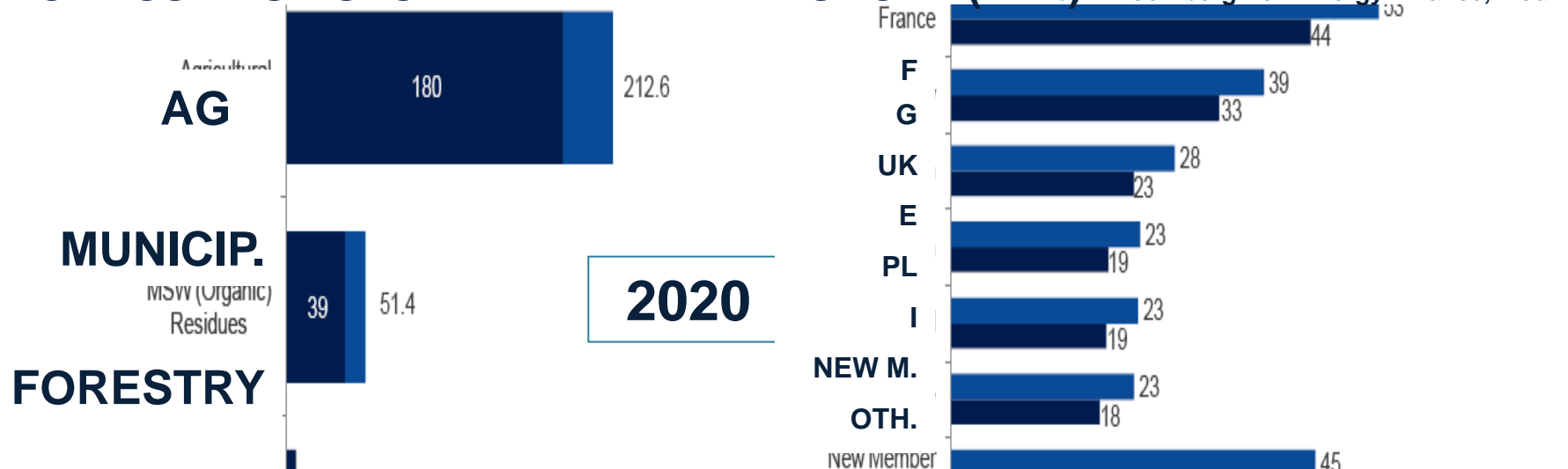
A SUSTAINABLE MIX OF CROPS & CROP RESIDUES



A SUSTAINABLE MIX OF CROPS & CROP RESIDUES (1)

- Cultivation of some annual crops and collection of crop residues help maintain rurality, agro-industry, and environmental biodiversity
- Wood (from coppice and SRF) and collection of forestry residues may represent a further income for farmers, and an ecological control tool of fires & slope erosion

BIOMASS RESIDUES AVAILABILITY IN EUROPE (ML t)—Bloomberg New Energy Finance, mod.



A SUSTAINABLE MIX OF CROPS & CROP RESIDUES (2)

- However, some perennial “backbone” crop must be present: a productive, adaptable, undemanding crop, with an extended harvesting period, to fulfill processing plant requirements between different “collecting seasons” (e.g. “straw season”, “stover season”, etc.)
- Farmers will have a more positive attitude towards a supply chain based on a mix of perennial & annual crops + crop residues, allowing them to operate continuously through the year, and face better market uncertainty

PERENNIAL RHIZOMATOUS GRASSES: IDEAL CROPS FOR BIOFUELS PRODUCTION (1)

- Higher yield potential, as compared to annual crops
- Limited ecological/climate demands, better WUE & NUE
- Favorable environmental impact in terms of Carbon balance, improved soil quality and energy balance
- Adaptation to saline soils and saline waters
- No crop rotation: less energy related consumption
- Field storage → harvest & transport to the biorefinery on a “JUST-IN-TIME” strategy basis
- Multiple end uses: LC ethanol, C6-C5 sugar Refinery, CHP cycles, mixed uses → more market opportunities

PERENNIAL RHIZOMATOUS GRASSES: IDEAL CROPS FOR BIOFUELS PRODUCTION (2)

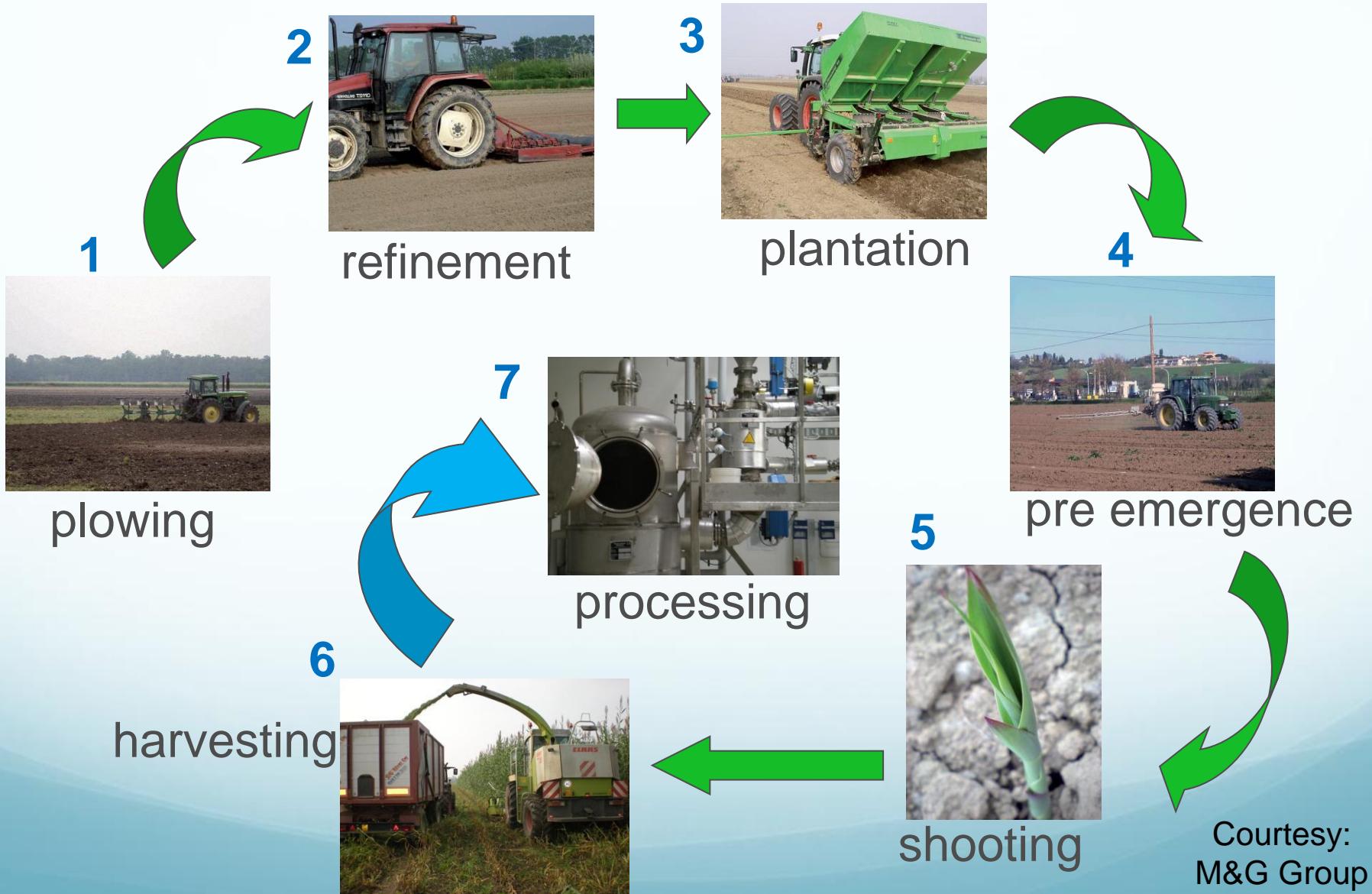
- Pollen free → low cross-fertilization risk → stable genotypes
- Most insect repellent
- Phytoremediation
- Lower soil erosion risk, due to better rainfall interception, surface cover for longer time, and massive root system
- Well suited to marginal sites → less competition for land use with food crops
- Easy control of escaped plants with glyphosate

GIANT REED (*Arundo donax* L., Adx)

The leading candidate among potential ligno-cellulosic feedstocks in warm temperate & Mediterranean climates:

- Already a part of several natural landscapes (native to India)
- High yield of ethanol per hectare, with low ecological demands
- High photosynthetic capacity, absence of light saturation
- Tolerant to a wide range of soils; adaptable to saline soils & waters;
- Low nutrient and agrochemical requirements
- Positive associations with microorganisms, especially endophytic and mycorrhizal fungi
- Reduced/No tillage during crop cycle increases soil OM and microbial biomass, as compared to annual crops

Adx CULTIVATION PROTOCOL



Courtesy:
M&G Group

CLAIMS ON “INVASIVITY” OF Adx

- Named as one of the top 100 Worst Invaders of the World
- Asexual reproductive species although produces flowers: spreading is related only to rhizome transport
- Invasivity is site-dependent: grown away from riparian areas (=areas adjacent to streams & rivers, prone to flooding), it is not an invasive plant
- Buffer strips of some turf species may be used along riparian areas to further control any chance of spreading
- Should it escape from upstream cultivations, it can be easily controlled with glyphosate
- Briefly, its present invasivity potential is not greater than that of volunteer sunflower or beet, and less than that of Johnsongrass-Sorghum halepense (where glyphosate-resistant types were identified)

CONTROL OF SPREADING (DURING & AFTER)



A yearly maintenance of a border (=buffer) strip around fields avoids any uncontrolled spreading

After a 10-year cycle, root system can be removed by a sequential treatment of glyphosate after last cut + rhizome mechanical removal



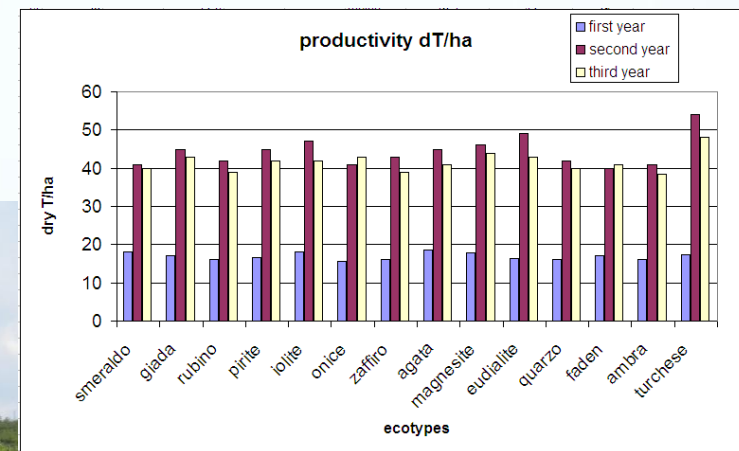
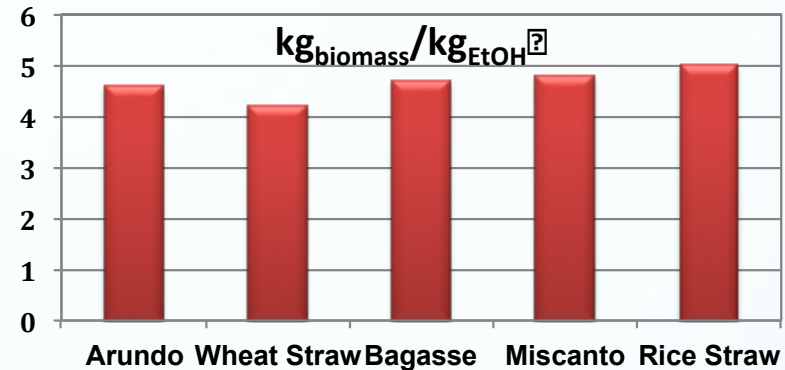
CONTROL OF SPREADING (in the long run)

- No problem of unwittingly spreading under cropping conditions, as indicated by the Torviscosa (Italy) experience in 1930-1960s in Northern Italy
- Here *Adx* -for the first time- was extensively cultivated on a large scale basis (>6 000 ha) as an energy crop and a cellulose source for over 20 yrs, with no problem of long-term containment in the cultivation area
- Presently the area is cropped with corn-soybeans-wheat, and *Adx* presence is limited to small natural patches



M&G GROUP'S RESEARCH ON LC CROPS & Adx

- LC crops for biofuels adapted to different locations:
 - Southern Europe,
 - Mediterranean areas,
 - other World areas
- *Adx* ecotype plot & field tests



Courtesy:
M&G Group



BETA Renewables's CRESCENTINO PLANT



<http://www.biofuelsdigest.com/bdigest/2012/09/18/tranquility-base-here-the-crescentino-project-has-landed/>

MAJOR RESEARCH AREAS ON Adx AT THE DiSAAA-UNIVERSITY OF PISA

- Crop resistance to:
 - environmental stress: heat, freeze
 - soil stress: salinity, anoxia
- Effect of plant mycorrhizal infection on early growth, water stress resistance, photosynthetic activity
- Micropropagation and somatic embryogenesis vs. rhizome and cane propagation

**BIOLOGY &
AGRONOMY
ISSUES**

- Effect of irrigation and Nitrogen fertilization on the crop growth in its establishment year
- Innovative harvest equipment for improved field storage

in collaboration with CHEMTEX AGRO



MAJOR RESEARCH AREAS ON Adx AT THE DiSAAA-UNIVERSITY OF PISA

- Leading crop for Nitrate Vulnerable Zones (NVZ):
management & reclamation
- Soil bioremediation (heavy metals)
- Energy crop (exhausted lignin) for CHP cycles, both for
dedicated plants & on-farm burners (e.g. curing barns of
Virginia Bright tobacco)

**ENVIRONMENTAL
ISSUES:
CROP & PROCESS**

- Evaluation & recycling as a plant nutrient source of:
exhausted lignin-ashes from Adx & other biomass
feedstocks, and of "wastes" of a LC biorefinery

in collaboration with CHEMTEX ITALIA

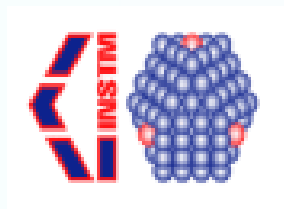


Adx: VIEWPOINTS, BRIEFLY

- **FARMER:** It's a financially attractive option, preferable to other energy crops, for its high and stable (10 yrs) yields, low production costs, and capacity to exploit marginal lands
- **INDUSTRY:** It's a high quality feedstock, with an ample and flexible harvesting "window", favorable storage & bulk density. High quality, recyclable, post-process "wastes"
- **AGRONOMY:** It helps reduce Nitrogen runoff into waterways and increase Carbon sequestration. It adds value to marginal (saline, polluted, non-irrigated) lands, unsuitable for row crop production
- **ENVIRONMENT:** It's a natural presence in several areas. Due to high yields (bulk density: 105 kg/m^3), less land and logistics (traffic, emissions) are required to feed a biorefinery. It helps in bioremediation programs

CONCLUSIONS

- *Adx* offers substantial advantages over other potential biomass crops for yield, quality, low ecological demands, and post-process “wastes” recycling
- It represents an ideal backbone crop for any biomass supplying chain based on a mix of perennial & annual crops + crop residues
- Any sustainable, biomass-based energy/fuel production chain, to be productive, economical, environmentally oriented, and socially viable should be **agronomically designed on/to the site**, maintain biodiversity, and respect farmers’ convenience (and freedom) to become an active part of it



Thank You



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